EXPERIMENTATION:
Engine for Applied Research and Technology Transfer in Software Engineering

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Motivation

- **Gap between 'state of research' and 'state of practice' in software engineering much wider than in other technology fields!**

- **Many innovative technologies not lived in practice**

- **Body of knowledge in software engineering dominated by**
    - **languages, techniques & tools**
    - **rather than methods and knowledge regarding their effects in real settings**

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Experimentation:

- **Experience is knowledge based on actual application**

- **Experimentation comprises all forms of systematic hypothesis testing leading to explicitly documented and therefore sharable experiences**

- **Experimental forms range**
  - **from fully controlled laboratory experiments**
  - **to case studies**

- **Such experimentation is**
  - **a prerequisite for sustained learning & improvement**
  - **applicable in research/teaching&training/tech transfer**

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Role of Experimentation in Software Engineering:

- **Most software engineering technologies are human-based**

- **Experimentation enables sustained learning**
  - **about the effects of new technologies (e.g., effort)**
  - **about the impact of (human) variation factors (e.g., experience with application)**
  - **'whether it works for ME?' (motivation for process conformance)**

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Available "Tool Box" for Experimentation in SE:

- GQM measurement approach (Basili et al)

- QIP experimental method (Basili et al)

- EF laboratory set-up (Basili et al)

- Experimental design types (Selby et al)

- Analysis methods (for non-parametric SE data) (Briand et al)

- Reference laboratories (e.g., SEL, IESE, CAESAR)

- Exchange forums (e.g., ISERN, SEC)

- Conferences & journals (e.g., Metrics, SEL-WS, JESE)

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Fraunhofer IESE: ... built on the Experim. Paradigm:

- **Institute for Experimental Software Engineering (IESE)**
  - experimental process engineering
  - enables predictable product engineering

- **Founded on 01 January 1996**

- **Mission**
  - help German/European/... companies in
    - building up learning organizations for software business based on QIP/EF approach
    - transferring innovative software development technologies into practice fast and with limited risk

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Fraunhofer IESE: ... built on the Experim. Paradigm:

- **Inheritance from NASA's SEL**
  - **Concept of software engineering laboratory environment was adapted to Germany**
    - customer/developer/researcher collaboration
    - experimentation as major research/transfer vehicle
    - long-standing relationship to build up mutual trust
  - **I was trained/learned in SEL environment (84-91)**
    - dual role of university research & practice involvement
    - research & technology development focused on practitioner's needs (= applied research)
  - **Reference to SE was key argument to get govern-ment & industry support in Germany (in 1995!)**

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Fraunhofer IESE: ... built on the Experim. Paradigm:

- **Differences compared to NASA's SEL**
  - separate legal entity

    Provide business plan for 140 employees!

  - different culture regarding industry/university collaboration

    Convince academics & industry of benefits!

  - strategic relationships with many companies from many different sectors (IT, Telecom, Automotive, Aerospace, Banking/Insurance)

    Provide critical mass in core competence areas!

    Combine application knowledge with SE competence!

  - collaboration with competing companies

    Provide solid mechanisms for confidentiality/security!

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Useful Applications ... (Applied Research):

- **Applied software engineering research should produce**
    - **new/refined technologies**
    - **together with experiences regarding its effects**
    - **in a specific setting (constraints)**

- **Experiences have to be the result of some form of experimentation**

- **Experiments have to be repeatable**
    - **requires sound documentation (in publications)**
    - **otherwise no contribution to state-of-the art**

- **There are no unsuccessful, only poorly designed experiments**
    - **rejections of hypotheses are also valuable**
    - **qualitative analysis points out reasons for rejection = new hypotheses!**

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Useful Applications ... (Applied Research):

- **Examples**
  - **step-wise abstraction reading of code is more effective & efficient for defect detection than testing and other reading techniques**
    - **initial study in SEL [Selby et al]**
    - **replications at universities (e.g., Kaiserslautern [Lott])**
    - **replications in companies (e.g., Bosch Telecom)**
  - **perspective-based reading of informal require-ments is effective and efficient for defect detection than other reading techniques**
    - **initial study in SEL [Basili et al]**
    - **replications (e.g., Kaiserslautern [Laitenberger])**

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Useful Applications ... (Applied Research):

- More studies on more topics are needed!
- Join the **I**nternational **SE R**esearch **N**etwork
    - -> www.iese.fhg.de/ISERN/
    - -> isern@informatik.uni-kl.de

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Useful Applications ... (Teaching & Training):

- **SE education should include**
  - **teaching of experimental methods**
  - **their application to 'self experience' important sw engineering principles (e.g., inf. hiding)**

- **SE education without experimentation will not affect long-term development behavior**

- **SE training should include**
  - **'experimentation' with new technologies to judge their applicability in work context**

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Useful Applications ... (Teaching & Training):

- **Experimentation is class subject (e.g., CMSC 735)**

- **Examples of graduate software engineering class experiments in Kaiserslautern**
  - **experience the superiority of code reading over unit testing**
  - **experience the advantages of good OO designs (inf. Hiding, etc.) for maintenance**
  - **experience the benefits of tractable documentation for maintenance**
  - **experience the superiority of perspective-based reading of informal requirements over other reading techniques**

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Useful Applications ... (Teaching & Training):

**Lab manuals of all classroom experiments
are available for replication!**

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Useful Applications ... (Technology Transfer):

- **Technology transfer**
  - **convinces personnel of benefits**
    - **top management to invest**
    - **project management to support**
    - **project personnel to 'live' new technology**
  - **adapts generic technologies to company needs**
  - **optimizes new technologies within organization**
  - **re-enforces use and sustains gains**

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Useful Applications ... (Technology Transfer):

- **Example (from Fraunhofer IESE)**
  - Bosch Telecom, Germany (private networks)
  - Problems with late problems (and rework)
  - Idea: Introduce 'PBR-based inspections for requirements'
  - Procedure (3 years, about 6 PY effort on IESE side)
    - Step1: Reference existing experiments (SEL, IESE)
    - Step 2: Repeat PBR experiment with developers
    - Step 3: Adapt/package PBR for use in pilot project
    - Step 4: Evaluate results from pilot project (- 40% rework!)
    - Step 5: Optimize effects in follow-ups (> -90% rework!)
    - Step 6: Roll-out to all projects (Frankfurt)
    - Step 7: Roll-out to different sites (Germany, France)

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Useful Applications ... (Technology Transfer):

Companies experience

    - sustained improvements

    - return on investments from improvements

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Outlook:

- **Experimentation will become an essential sub-discipline of software engineering**
  - **to speed up the accumulation of shareable, testable & repeatable knowledge (research)**
  - **to raise a generation of true software engineers (teaching & training)**
  - **to speed up the infusion of innovative technologies into practice (technology transfer)**

Experimentation is the engine to speed up the transfer of applied research results into practice!

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Outlook:

- **More organizations (academic laboratories & industrial learning organizations) need to be based upon the experimental paradigm**

- **The SEL has been for ESE what the SEI has been for assessment! It started a movement!**
  - **Fraunhofer IESE is an offspring of NASA's SEL**

I wish the SEL a successful future!
May it be valued inside NASA as highly as it is regarded outside!

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